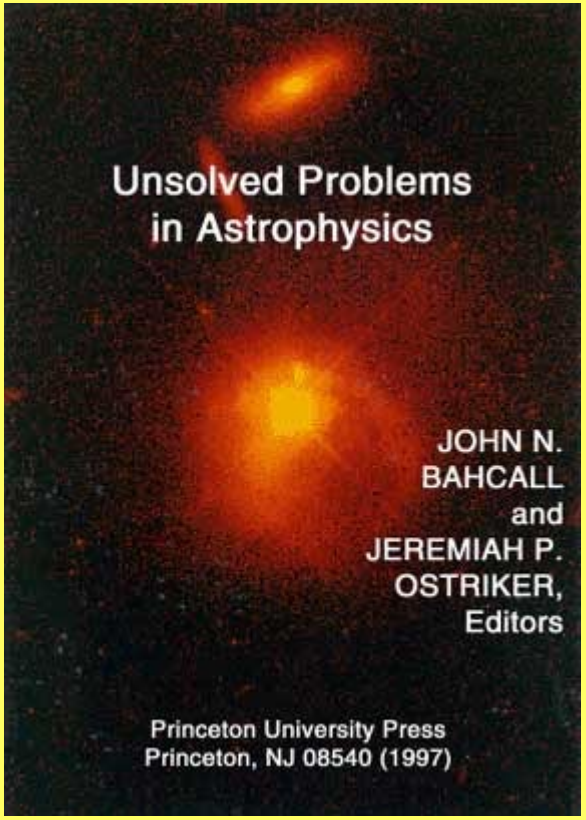
Earth Science Workshop
National Underground Science Lab



- **From Cosmo to Earth: NUSL**
- **Six Sessions: Multi-Disciplinary**
  - **thermal tests, coupled processes**
  - **hydrology, heterogeneity**
  - **geology, mapping and training**
  - **geochemistry, ecology, biology**
  - **geophysics, seismology**
  - **rock mechanics, geotechnical engineering, operation, safety**

Contact: Joe Wang, jswang@lbl.gov

NUSL Earth Science Participation

Earth Science Program

1. **Basic Research Activities**
2. **Unique Educational Programs**
3. **Long Term Mine Safety**

NUSL Earth Science Recommendations

1. **Maintain accessibility to the Whole Mine.**

   - **This is a top priority for the Earth Science community.**

   - **This issue needs to be conveyed to everyone prior to mine shutdown, before any parts of the mine are made inaccessible. All Levels of the mine have potential scientific value.**

2. **Gain access to Entire Archive of existing data and samples gathered during the mine's 125 year history.**

3. **Characterize geology, seepage (groundwater), and other mine information for test site selection, including anecdotal information from current and past employees.**

4. **Plan and conduct testing, monitoring, and training activities at NUSL, as a Center for Deep Science.**

How NUSL Fits into Earth Science Activities ?

David Lambert, NSF/GEO/EAR Instrumentation and Facilities

- **EAR-NUSL Interfaces**
- **“Critical Zones” between Biosphere and Underground**

Dennis Nielson, DOSECC / U. Utah

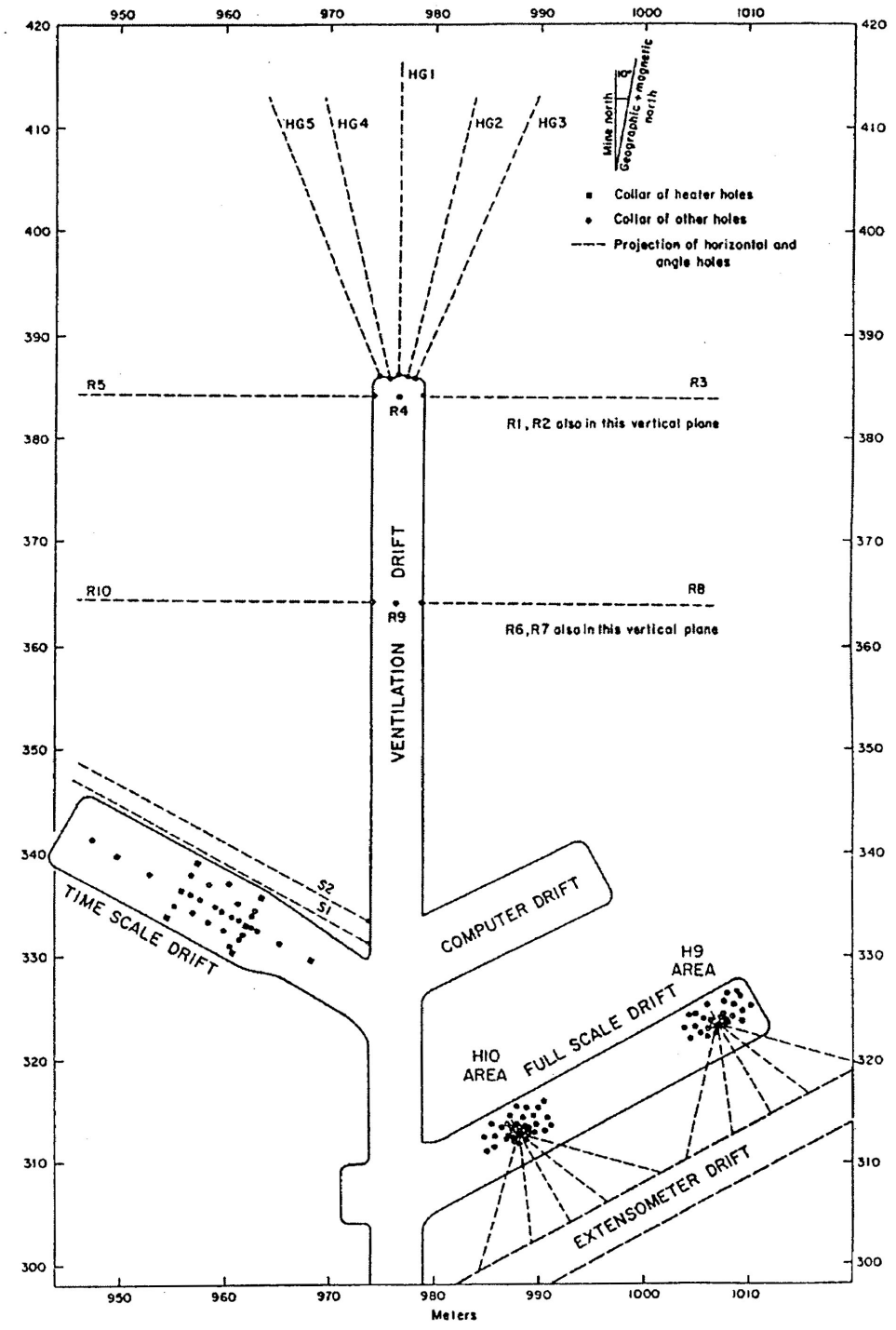
- **Interests in Earth’s Continental Crust**
- **Deep Scientific Drilling - Hawaii, San Andrea Fault, Yucatan Peninsula / Earthscope**

Earth Science Underground Testing

(Examples for Comparison)

	Homestake	Stripa - Swe.	WIPP	Yucca Mt.
Depth	**8,000 ft**	**1,100 ft**	**2,000 ft**	**1,000 ft**
Duration	**~ 30 yr**	**2 - 10 yr**	**3 yr.**	**6 yr.**
Rock	**Metamorphic**	**Granite**	**Salt**	**Tuff**
Levels	**~ 50**	**1 - 2**	**1**	**2**
Mission	**Research**	**Research**	**TRU Storage**	**HLW Repository**
Facility	**Gold Mine**	**Iron Mine**	**New Shafts**	**New Ramps**

Conversion of an Iron Mine into an Underground Lab in Three Months at Stripa, Sweden in 1977



How Does Fractured Rock Respond to Thermal Loading ?

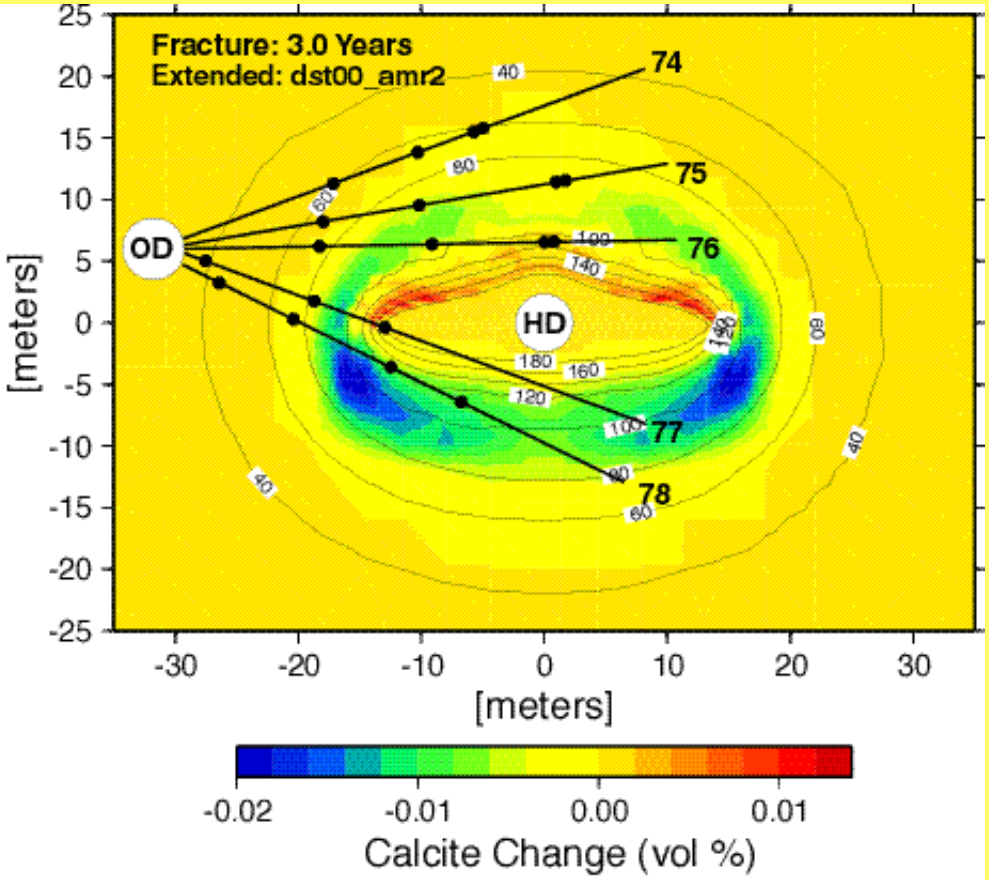
How do thermal (T), hydrological (H), chemical (C), and mechanical (M) coupled ?

Does the fracture flow paths for vapor and liquid change spatially and temporally from mineral dissolution and precipitation, and from rock deformation and shear ?

Workshop Speakers:

Paul Witherspoon, UC Berkeley / LBNL
Eric Sonnenthal, LBNL
Herb Wang, U. Wisconsin
Elfadi Azrag, HCItasca
Hiroshi Takahashi, BNL (Underground Reactor Testing)

Reaction-Transport Processes



At Homestake, will the mineral redistribution greatly changed in the presence of Fe- and Mg-Rich mineral assemblage (with fabric and ore minerals) of metamorphic rocks ?

At Yucca Mountain, relatively small porosity change is expected for tuff rocks.

How Does the Flow and Transport Change with Scales ?

How do surface recharge and climate affect (potable) groundwater resources for local and distant communities?

Is Black Hills a typical Regional Recharge Zone ?

Is the ventilation remove enough moisture to suppress observations of seepage (inflow) into drifts ?

How to use drifts and ramps to quantify drift-scale parameters at Homestake ?

How to use the rocks at Homestake for multi-scale water and CO_2 evaluations ?

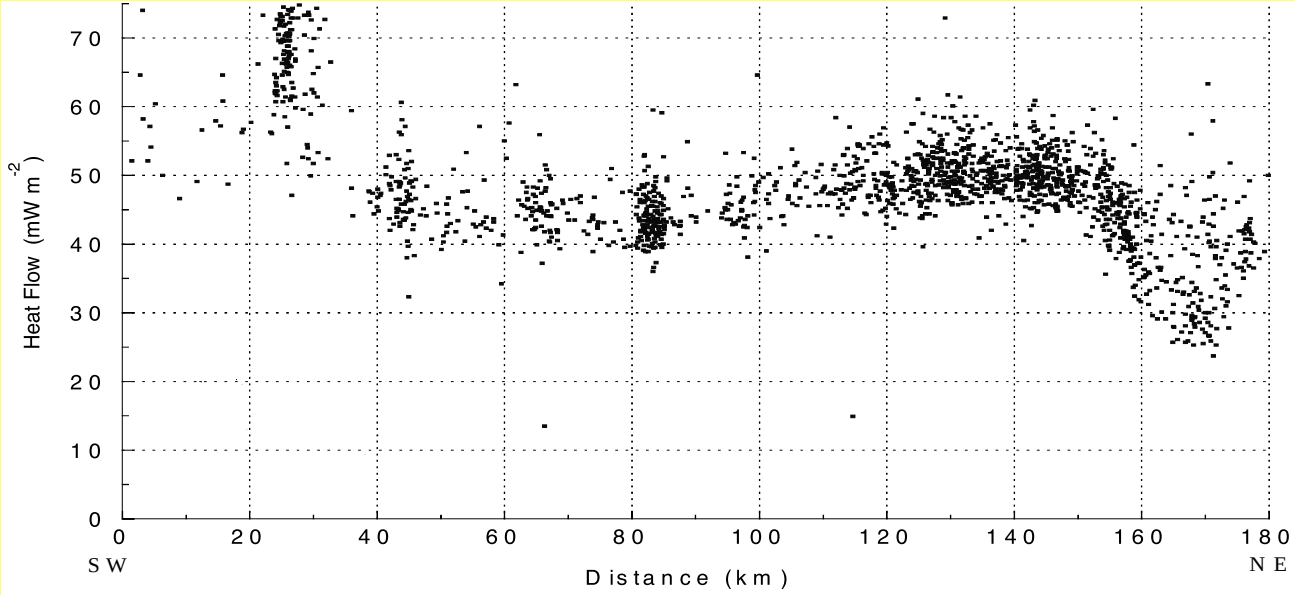
Workshop Speakers:

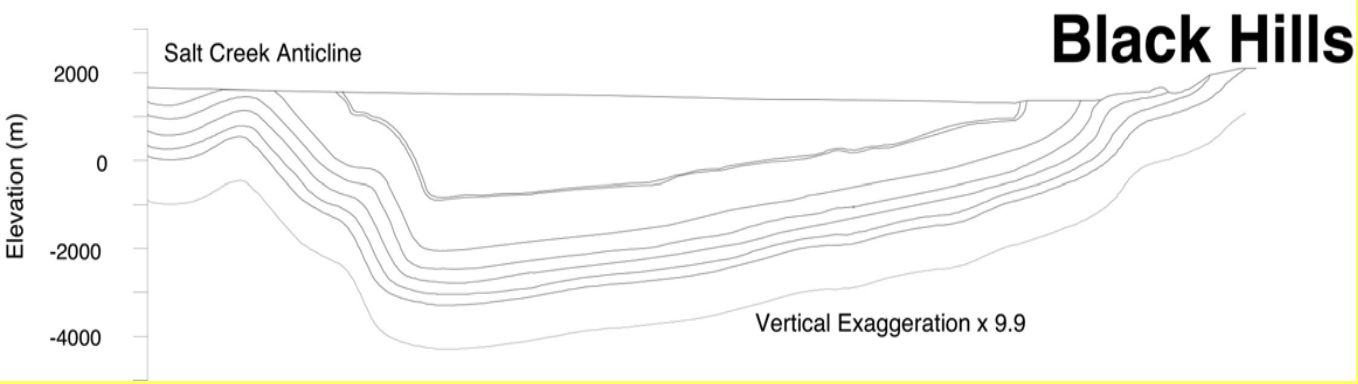
Ed Weeks, US Geological Survey

Brian McPherson, NM Tech.

John Gale, Memorial U. Newfoundland, Canada

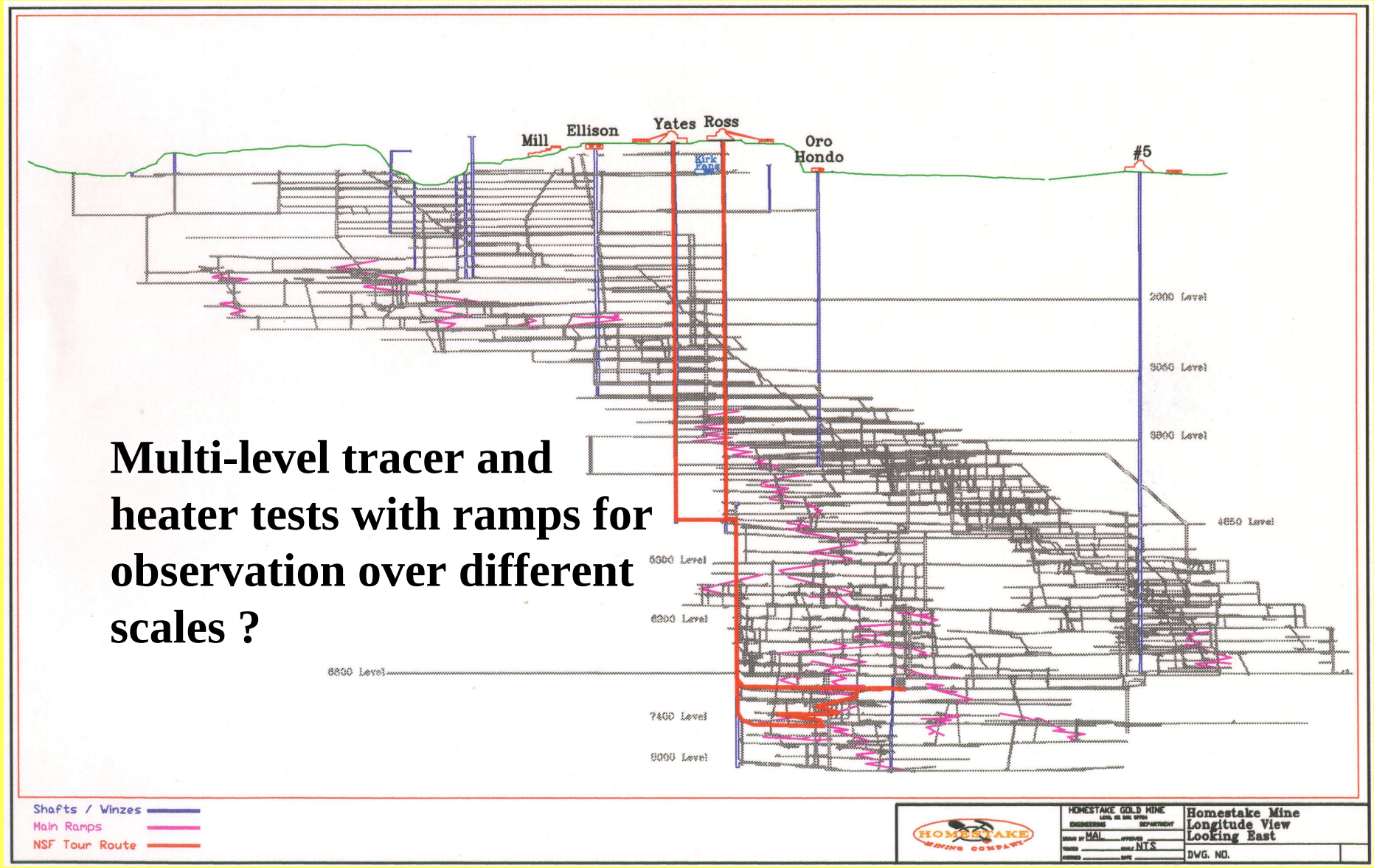
How does the mine affect regional groundwater flow?





Example:Power River Basin with Black Hills as a Recharge Area

NUSL for Large-Scale Long-Term Tests



Multi-level tracer and heater tests with ramps for observation over different scales ?

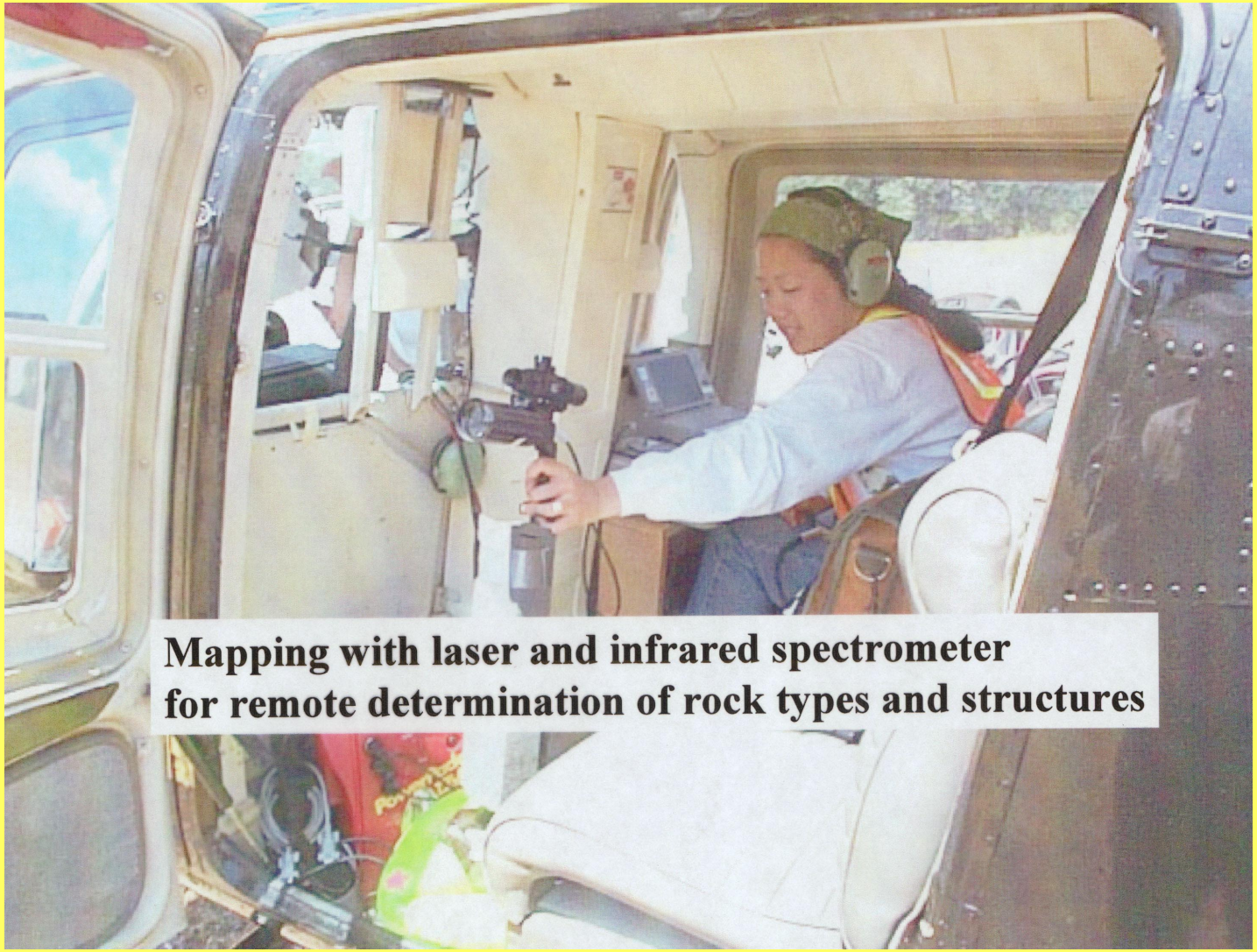
How to Effectively Preserve Geodata and Mining Experience?

How to effectively preserve data for use by scientists and engineers?

How to use NUSL for training of geologists and mining engineers for underground excavation ?

Workshop Speakers:
Edward Duke, Tom Campbell, and Ziggy Hladysz, SDSM&T
George Brimhall, UC Berkeley

Implement Digital Mapping in New Excavation, and Train Geologists and Engineers



Mapping with laser and infrared spectrometer
for remote determination of rock types and structures

What is importance of Homestake to continuing efforts to understand geochemistry of ore deposits?

Homestake is <u>largest gold deposit in North America</u> and a target for mineral exploration throughout world

It was formed by hydrothermal fluids…possibly as much as 30 km^3 of fluid…but we do not know the source of fluid or gold

Great depth of mine allows us to study this hydrothermal system over a much larger vertical interval than can be studied in most other parts of Earth's crust

<u>Workshop Speakers</u>:

Edward Duke, SDSM&T

Stephen Kesler, U Michigan

Jaakko Putkonen, U Washington

Possible sources of fluid and gold:

1) metamorphism of Proterozoic host rocks

2) intrusion of Proterozoic granites

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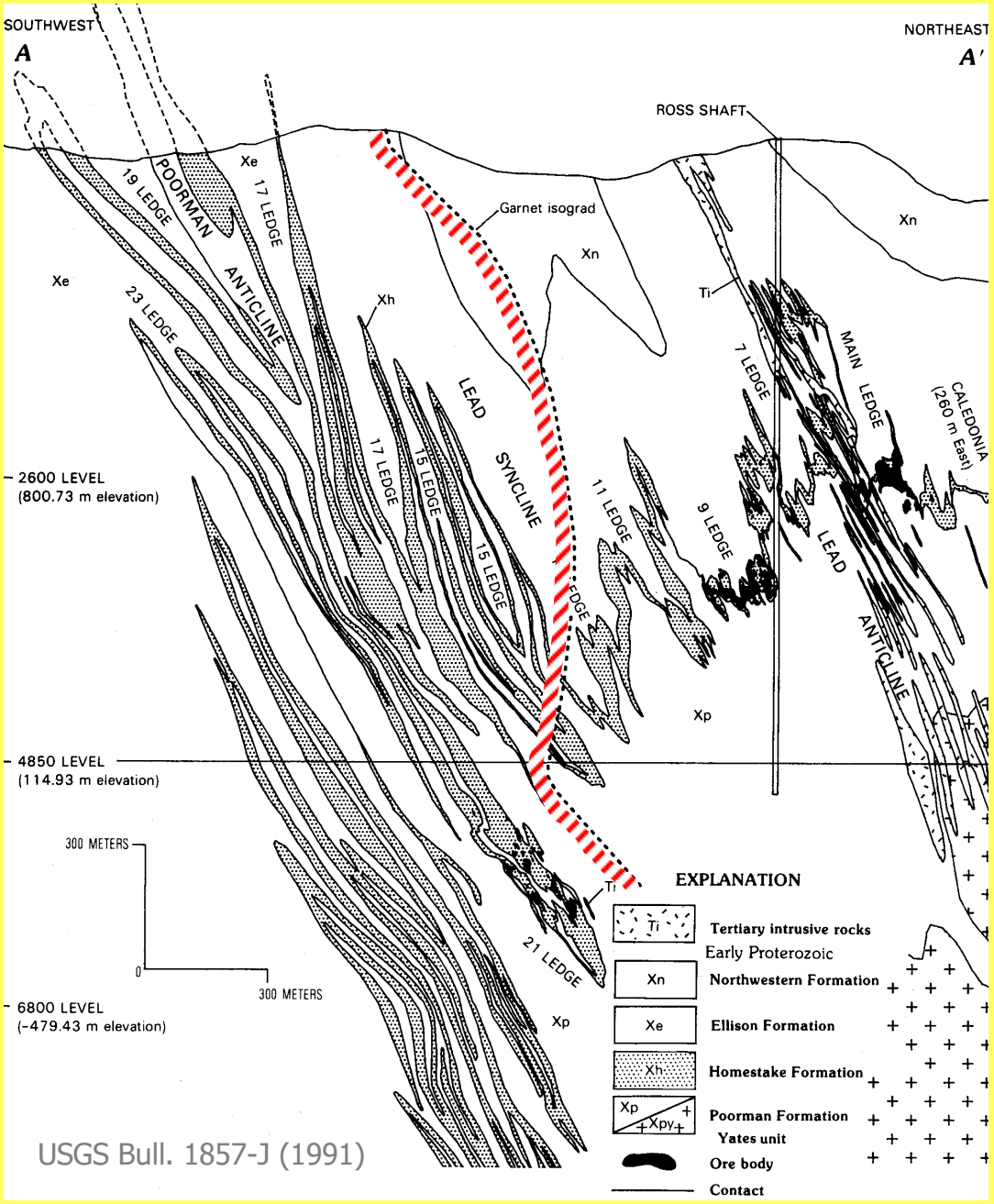
information needed on geologic and age relations between ore and these events

- note close association of ore with metamorphic isograd (red)



USGS Bull. 1857-J (1991)

Information is also needed on chemical conditions of ore deposition:

Sulfidation of wallrocks appears to have been important reaction in ore formation, but T and P of these processes are poorly known

What are the Main Concerns about Toxic Material Release and Bacteria Growth?

Will toxic substances in the mine mobilize with flooding ? as illustrated in a Canadian example.

Will bacteria grow in extreme conditions, including the hot and humid conditions at 8,000 ft ?

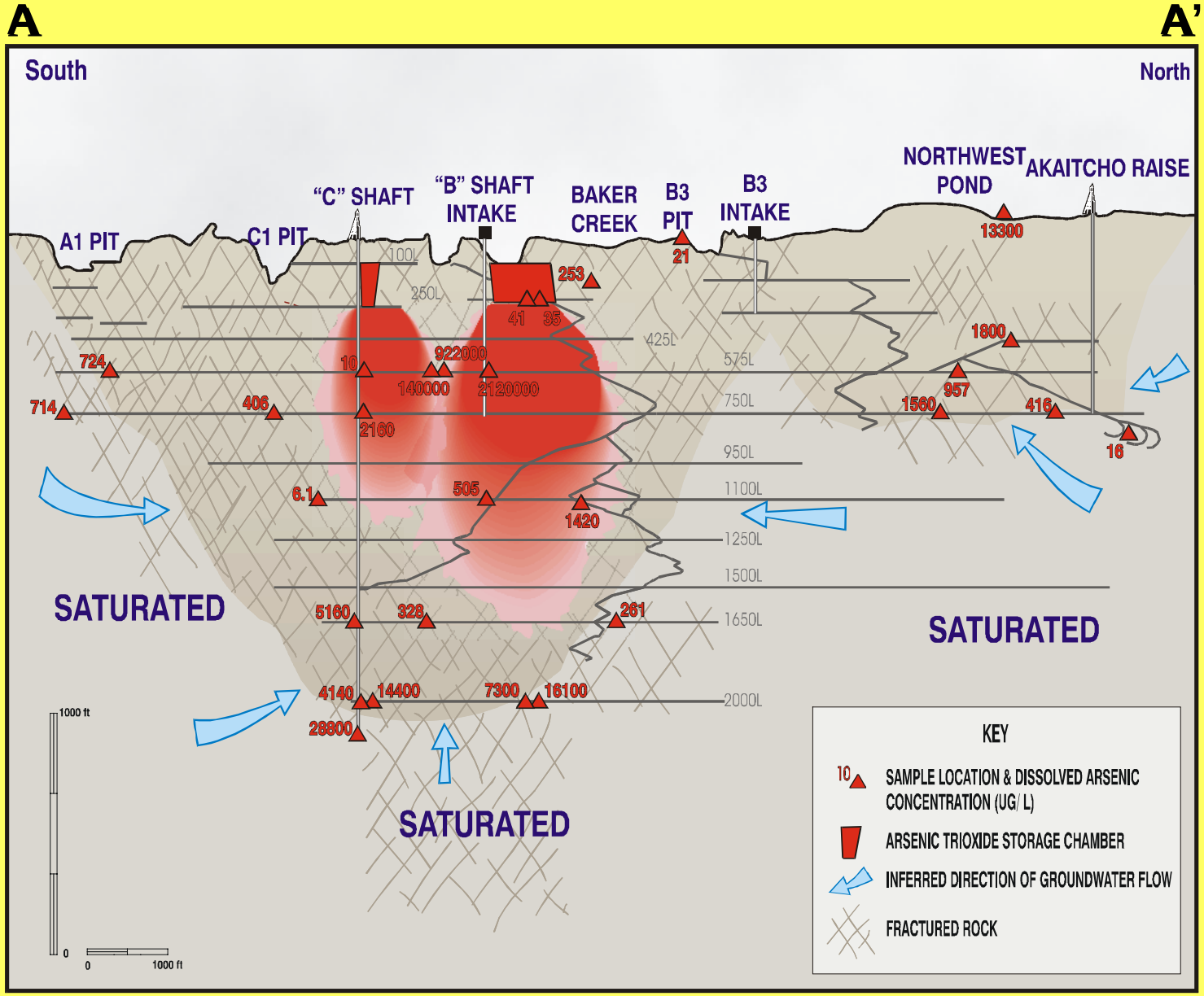
Does unique organisms exist at Homestake ?

Workshop Speakers:

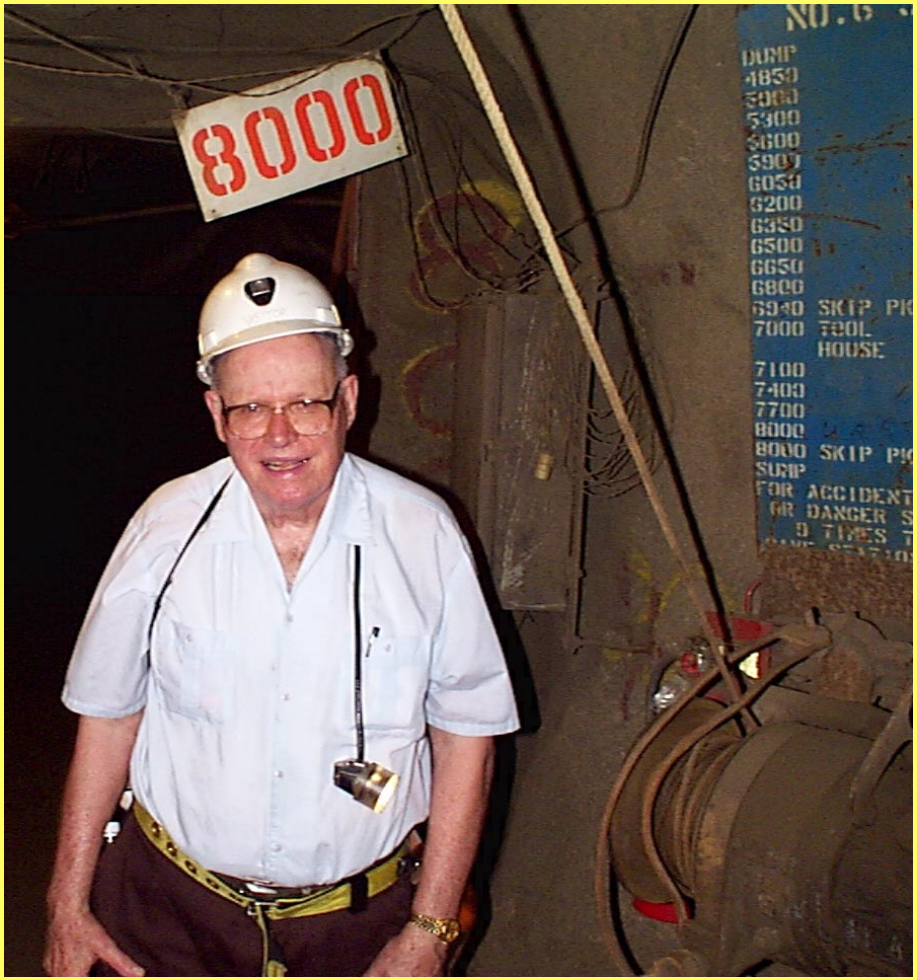
John Gale, Memorial U. Newfoundland, Canada

Terry Hazen, LBNL

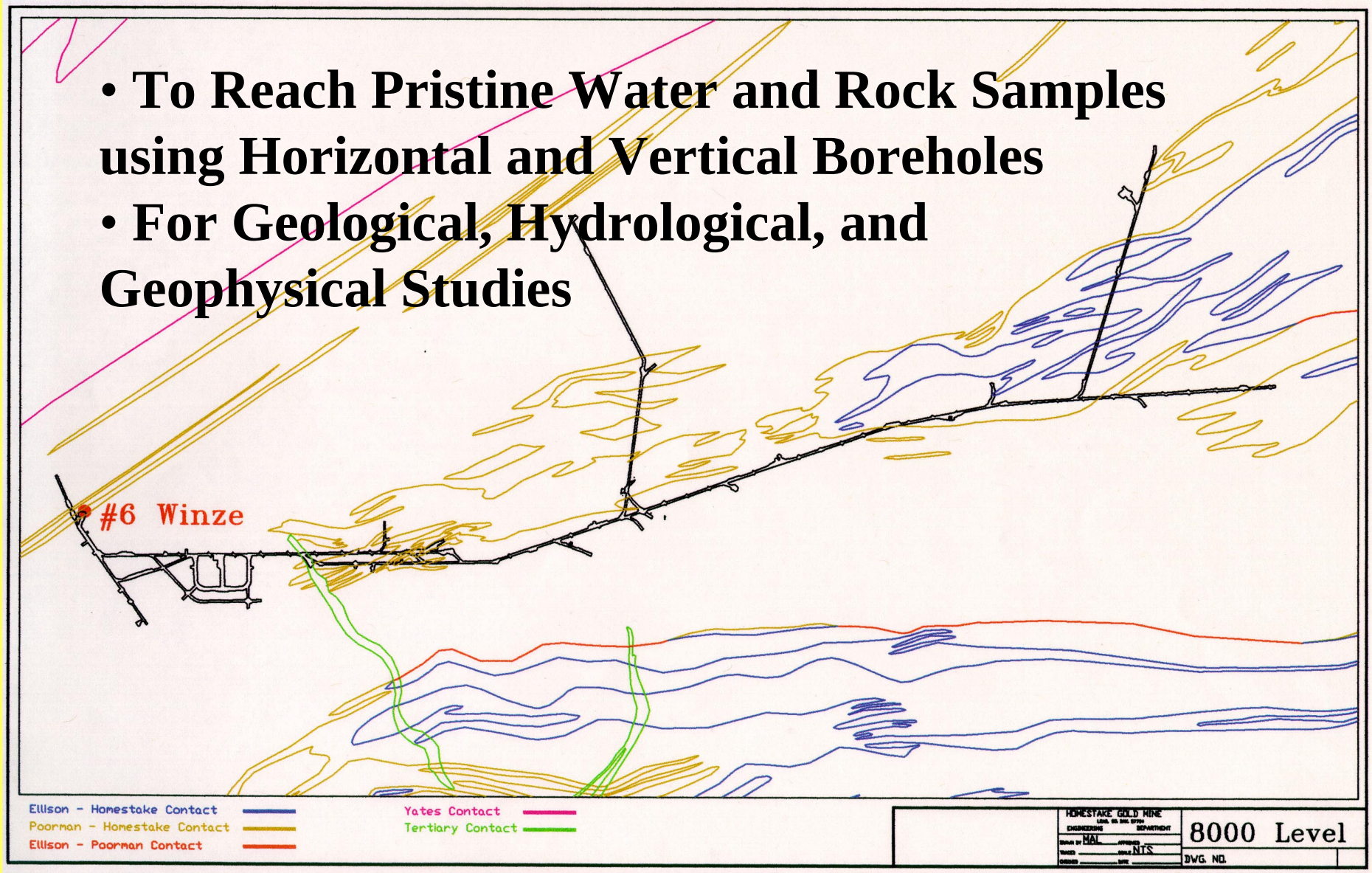
Vertical Section & Arsenic Plume



Homestake Mine 10/5/2001



Use of the Deepest Level at Homestake



How to Use Geophysical Imaging to Study the Solid Earth ?

Can shafts and drifts be used for large scale magnetic loop and electrical transmitters/antennas to study deeper structures in the crust ?

Can Homestake be used to either verify or deny the existence of a highly conducting deep layer in the crust ?

Can seismic stations in the deep mine installed for earth core imaging ?

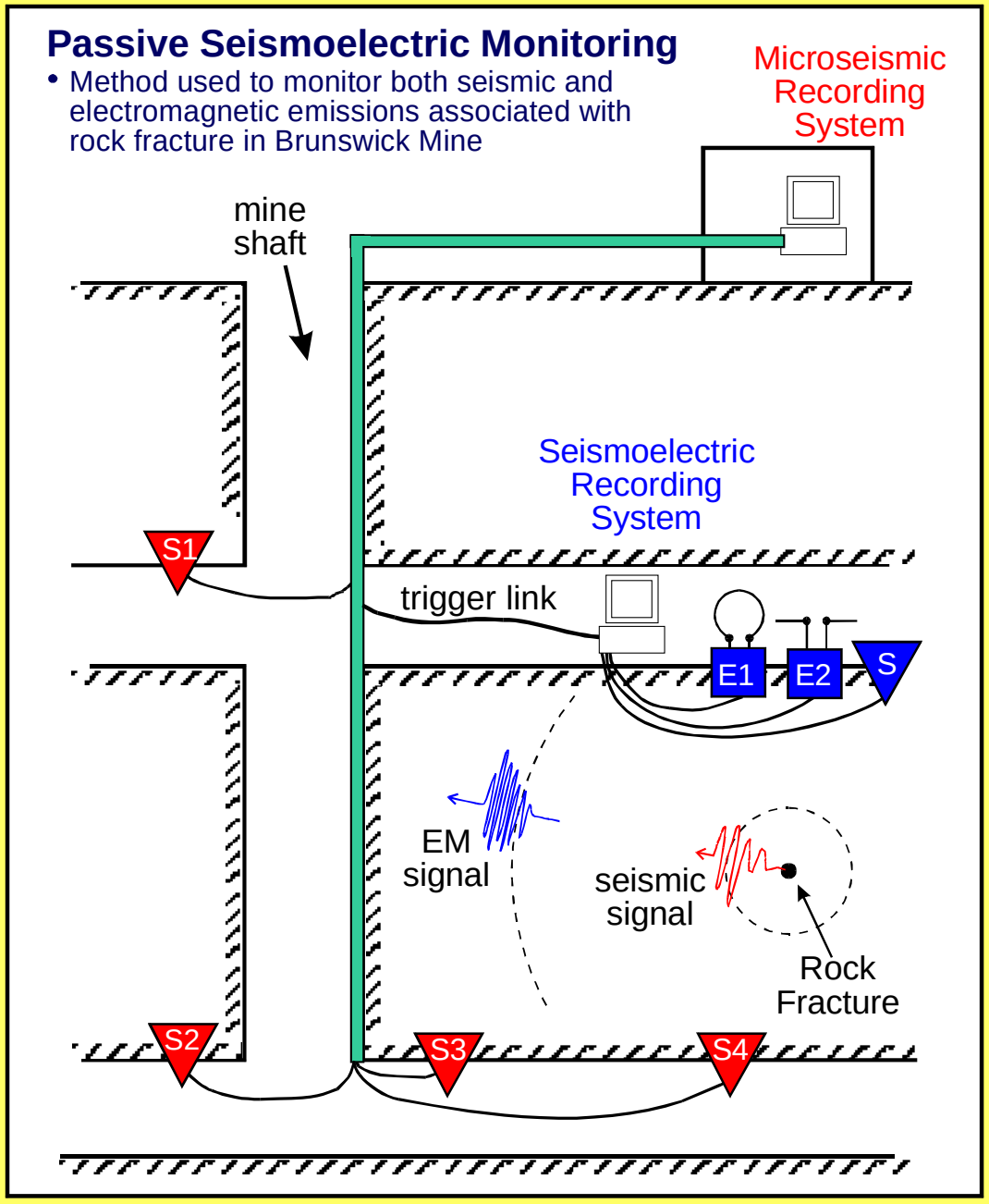
Can earthquake be predicted with EM signals associated with seismic events?

Workshop Speakers:

Misac Nibighian, Colorado School of Mines
Lane Johnson, UC Berkeley
Larry Myers, LBNL
Karl Butler, U New Brunswick, Canada

Passive Seismoelectric Monitoring

- Method used to monitor both seismic and electromagnetic emissions associated with rock fracture in Brunswick Mine



A parallel plate dipole (PPD) electric field antenna underground at Brunswick Mine (~1 kHz - 1 MHz bandwidth)

Karl Butler
University of New Brunswick

UNB UNIVERSITY OF NEW BRUNSWICK

Is it Feasible to Use Particle Detector to Characterize Heterogeneity?

Can cosmic ray detectors be used for crustal imaging ?

Can neutrino detectors be used for mantle imaging ?

Workshop Speakers:
Joe Wang, LBNL
Genet Duke, SDSM&T

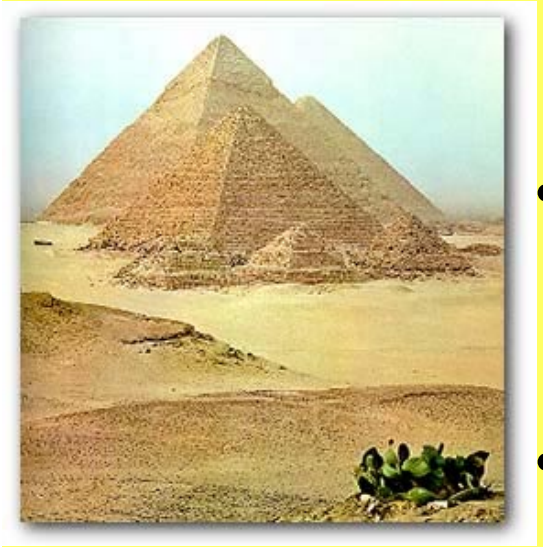
Structures Influenced/Quantified by Cosmic Ray (Muon) - Neutrino Detectors

- **Gran Sasso/MACRO - Italy (with ~ 10 years data)**
  - **Shadow of the Moon**
  - **Overburden of Mountain Ranges**

- **SNO - Canada (with ~ 0.5 year data)**
  - **Fault**
  - **Sand Filled Iron Ore Mining Region**

- **Homestake - NUSL (TBD)**
  - **Multi-Level Drifts**
  - **Folded Ore Bodies**

Archeological / Geological Cosmic Ray Imaging



Examples:

- **Absence of Hidden Rooms in a Pyramid**
  - UC Berkeley / Egyptian Gov.

- **Volcano Eruption Prediction**
  - U Tokyo

- **Historic Conservation**
  - Fed. Highway Adm.

Mapping of Cosmic Ray Flux at NUSL - Geophysical Imaging Development

- **Low Resolution (~ 3º) Mobile Sensor along Drifts**
- **High Resolution (~ 1º) Stations at Multi-Levels**
- **Calibrated with EM, Seismic Images**
- **3D Density Structure Modeling instead of 1D Standard Rock (Constant Density) Interpretation**

Can the Rooms Remain Stable and the Mine Operate Safely ?

Are the seismic monitoring network, stress-strain measurements, fire & ventilation system, emergency escape preparation, etc. adequate ?

Does the safety factor (e.g., for construction) large enough from civil engineering prospective ?

Workshop Speakers:
Karl Zipf, NIOSH
Chuck Nelson, CNA

Pending and Planned Actions

- **Follow-up meeting (in Lead, SD) in November, and**

2. **Poster presentation (in San Francisco, CA) in December at the American Geophysical Union 2001Fall meeting, to**
   - evaluate available seepage and whole mine layout formation
   - prioritize proposed activities
   - formulate the earth science plan.

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